Model-independent Mass-Radius Constraint for Neutron Stars

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While model-independent limits are always interesting, a limit on neutron star radius as a function of mass attains special interest in light of recent interpretations of the quasi-periodic oscillations (QPOs) in brightness of X-rays emitted from neutron stars that are accreting matter from a low-mass companion. Here we derive such a limit based only on well accepted principles, and discuss it in connection with the interpretation of QPOs in terms of mass and radius that are attributed to the star.

The tentative limits on mass and radius deduced from models of X-ray pulsations have been employed recently to discriminate among models of the equation of state of dense nuclear matter and even to suggest that one of the objects is a strange star candidate. Against this background our purpose is to derive a model-independent mass-radius constraint for neutron stars that depends only on minimal and well accepted principles. The limiting relation is analogous to a previously obtained lower limit on the Kepler period of a rotating star as a function of its mass.

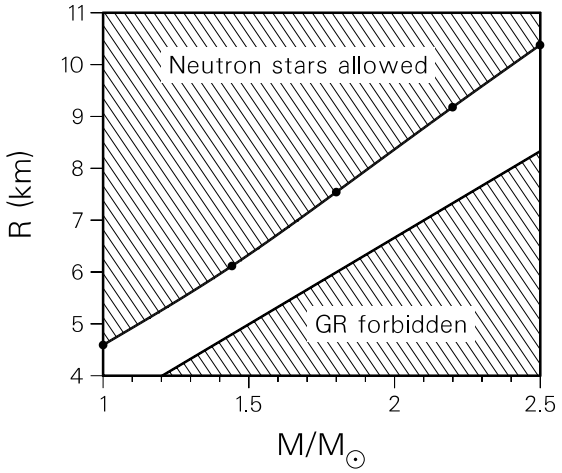

Figure 1: Allowed region of neutron star radii as a function of mass.

Our results are shown in Fig. 1. Neutron stars can have radii as small as those shown by the line, and otherwise must lie in the shaded region marked for neutron stars. In fact, strange stars have been considered as candidates that satisfy the constraints of the QPO phenomenon. Figure 2 illustrates the QPO limit obtained for a specific X-ray star together with the limit obtained in a model independent way. Neutron stars must lie to the right of our limit and the X-ray object must lie on or to the left of the line so marked. Clearly neutron stars cannot be ruled out, even if many explicit models can, always provided the QPO phenomena is modeled correctly.

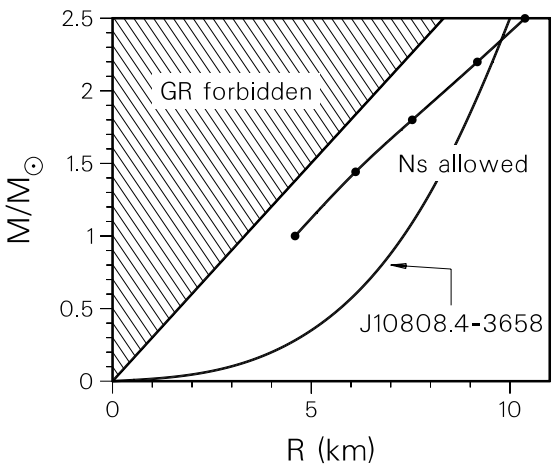

Figure 2: According to the QPO model the X-ray star must lie on or to the left of the curved line $R \propto M^3$ and by our model independent determination, neutron stars must lie to the right of the line marked 'Ns allowed'.